AMENDMENTS TO THE DRAWINGS

The attached sheet of drawings includes changes to Fig. 9b. This sheet replaces the original sheet including Fig. 9b. In Fig. 9b, the Bias was labeled as "+3VDC" and should be "-3VDC".

REMARKS

The Office has maintained the rejection of all claims based upon the same references. Applicant has provided herein further amendments and arguments that clarify the distinctions between the present invention and the cited references. The Applicant respectfully requests that the Office enter these amendments and place the application in condition for allowance or appeal. No new matter is added.

Telephone Interview

Applicant believes that the explanations and amendments herein place this application in condition for allowance. However, if any of the currently pending claims are rejected, Applicant respectfully requests a telephone interview to further clarify any remaining issues.

Drawings

The Office keenly noted that Fig. 9b had a bias labeled as "+3VDC" which should have been "-3VDC" as noted in the description. Fig. 9b has been amended accordingly and review and acceptance is requested to replace the drawing sheet. No changes are required in the specification. No new matter is added.

Claims Rejections - 35 USC §112 First and Second Paragraphs

The Office has rejected claims 1-6, 8-17, 19 and 20 under 35 USC 112 first paragraph for failing to comply with the enablement requirement.

The first paragraph of 35 U.S.C. 112 provides:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The Office states that "the device is not considered enabled because Fig.s 9a and 9b show energy levels continuous across all of the wells where absorptions apparently are equal across the entire device, i.e. there is no apparent distinction between the well absorptions. The wells

appear to be able to absorb the exact same photon energies. Also the Fermi energy is straight across the the device whereas there is supposedly a bias across the device. The energy levels across the device also apparently show the wells to be "coupled" as a superlattice." (Office Action dated 2/21/2007, page 2)

The prior responses include further explanations and the Applicant suggests the Office review the prior responses. "A 'well spike' as defined in the present application as a potential barrier and effectively adjusts the ground state and thereby controls the spectral response of the quantum well by controlling the energy levels. As noted in the present application in Par [0067], "[t]he **well spike of the red well effectively adjusts the ground state, and not the excited states associated with the red well**." It is a potential energy spike and has a large and controllable effect on the energy level of the carriers within the well by adjusting the ground state. This spike can be positive or negative, wherein a positive spike at the well center will raise the ground state energy and move the spectral response to a longer wavelength, and wherein a negative spike at the well center will lower the ground state energy and move the spectral response to a shorter wavelength." (see Office Action Response dated 6/30/06, page 12)

For convenience, Figure 9a and 9b of the present application are included herein.

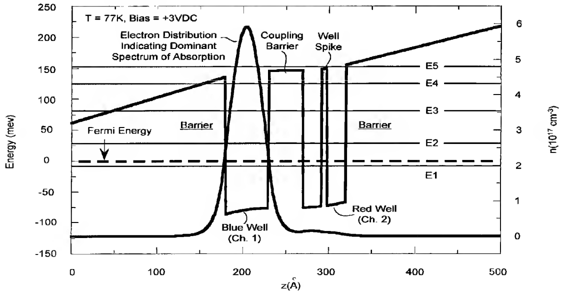

Fig. 9a

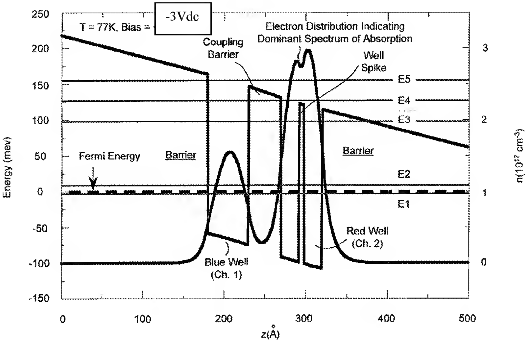

Fig. 9b

While the Applicant is not claiming a method for manufacturing, the "well spike" is a layer of material grown epitaxially in the middle of the quantum well layer as shown in Fig. 9a and 9b. An example is a layer of AlGaAs in the middle of a layer of GaAs wherein the AlGaAs is the "spike" layer and the GaAs is the quantum well layer. (see patent application Par [0067]) The "spike" is named as such because the potential energy for electrons (or holes) is higher in this layer than in the GaAs layers on either side of it. And the layer is designed to be very thin – for example, a fraction of a monolayer to one or two monolayers thick. The potential energy versus distance of this layer thus looks like a mathematical "delta" function, hence the name "spike". The term "well spike" is used because the spike is in the middle of the potential well (the well bottom being defined by the potential energy of the GaAs layer).

As noted in the present application, which is supported by the figures, "[0066] FIGS. 9a and 9b illustrate band diagrams, Eigenstates, and electron distribution associated with an asymmetric quantum well structure configured in accordance with another embodiment of the present invention. Here, the asymmetric well is provided by virtue of a unit cell that includes two coupled quantum wells. In particular, the design includes <u>a first quantum well configured to</u>

absorb a first spectrum (e.g., blue), a second quantum well configured to absorb a second spectrum (e.g., red), and a coupling barrier between the two wells. Outer barriers sandwich the coupled wells, and the second well includes a well spike. As noted therein, only the second well with the spike is doped.

[0067] The "blue" and "red" wells can be, for example, GaAs. Only the red well is doped. The barriers sandwiching the wells can be, for example, Al.sub.30%Ga.sub.70%As. The coupling barrier between the wells, and the well spike in the red well can also be Al.sub.30%Ga.sub.70%As. **The well spike of the red well effectively adjusts the ground state, and not the excited states associated with the red well.**"

Thus the structure of the well spike and the entire quantum well structure is described according to one embodiment and comports with the drawings.

In operation, the 'well spike' effectively adjusts the ground state and thereby controls the spectral response by controlling the energy levels. It is a potential energy spike and is very thin in relation to the well in which it resides as noted in the figures and has a large and controllable effect on the energy level of the carriers within the well. This spike can be positive or negative, wherein a positive spike at the well center will raise the ground state energy and move the spectral response to a longer wavelength, and wherein a negative spike at the well center will lower the ground state energy and move the spectral response to a shorter wavelength. (see Office Action Response dated 1/20/06 page 10)

The Office also asks for clarification as to the operation of the well spike. And in particular, how the well spike affects only the ground state energy and not the excited state energy.

"Par [0068] In operation, electron transfer from one well to another takes place when a bias is applied. Only the well which has electrons can absorb light, and therefore contribute to photocurrent. For example, with a positive bias (e.g., +3 VDC), the photocurrent generated in the

continuum is dominated by photo-excited electrons from the blue well, which has most of the electrons in it. The blue well peak response might be, for instance, at about 8.6 μm. On the other hand, with a negative bias (e.g., -3 VDC), the photocurrent generated in the continuum is dominated by photo-excited electrons from the red well, which has most of the electrons in it at this bias. The red well peak response might be, for instance, at about 10.0 μm. In such a positive/negative biasing scheme, note that only the downstream well absorbs photons. The lowest two subbands (E1 and E2) are occupied at 77K in this example."

The Office also requests further details concerning how the well spike adjusts the ground state without affecting the upper energy levels. The operation is based upon the well known first-order perturbation theory in quantum mechanics. This theory states that the energy (E) of a state is perturbed by a certain amount (DE) in response to a potential perturbation (V), where DE = <s|V|s*>, where s is the state wavefunction and s* is its complex conjugate. Expanding, DE = integral { s.V.s* dz } from z = 0 to infinity.

In the claimed device, the perturbation (V) is provided by the "spike" layer whose potential energy height is V. Even number states (2, 4, etc.) all have a null or zero in their wavefunctions (s and s*) around the center of the quantum well, where the thin "spike" layer (which is V) is placed. DE = 0 for these states. That is, their energies are <u>not perturbed</u>.

Odd number states, on the other hand, have a maximum in their wavefunctions (s and s*) around the center of the well. These states therefore experience a maximum energy shift given by (solving the above integral): DE = V.m.m, where V is the height of the potential spike, and m is the maximum value of the wavefunction (of course, s = s* for real wavefunctions such as these). This underlying principles for the quantum mechanics background information is available from numerous texts and treatises.

This is precisely one point of the claimed invention. **<u>The ground state (state 1) of the quantum well with the well spike can be adjusted to experience a positive energy shift (for</u>**

positive V), whereas the first excited state (state 2) experiences no energy shift. Higher energy states are of no relevance in this device.

Applicant thanks the Office for noting that this is a unique feature. No new matter is added as Applicant has continuously presented these features to the Office which are, of course, supported in the filed application. Review and allowance is respectfully requested.

Claims Rejections - 35 USC §112 Second Paragraph

The Office rejected Claims 1-6, 8-17, 19 and 20 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention. A §112 second paragraph rejection has two separate requirements, indefiniteness and failing to claim what applicant regards as the invention. With respect to indefiniteness, the "essential inquiry pertaining to this requirement is whether the claims set out and circumscribe a particular subject matter with a reasonable degree of clarity and particularity. Definiteness of claim language must be analyzed, not in a vacuum, but in light of (1) the content of the particular disclosure, (2) the teachings of the prior art, and (3) the claim interpretation that would be given by one possessing the ordinary level of skill in the pertinent art at the time the invention was made." (MPEP §2173.02).

The Office's focus during examination for compliance the requirement for definiteness of 112 (second paragraph) is whether the claim meets the threshold requirements of clarity and precision, not whether more suitable language or modes of expression are available. The essential inquiry pertaining to a rejection under 112 (second paragraph) is whether the claims set out and circumscribe a particular subject matter with a reasonable degree of clarity and particularity. MPEP 2173.02. This is an objective standard because it is not dependent on the views of applicant or any particular individual, but is evaluated in the context of whether the claim is definite – i.e., whether the scope of the claim is clear to a hypothetical person possessing the ordinary level of skill in the pertinent part. MPEP 2171.

As detailed herein, the well spike structure has been explained. The 'means for adjusting' the well spike is provided by an example in Par [0068] that explains how the biasing scheme operates in connection with Fig. 9a and 9b. Claims 3, 9, 10, 12, 19, and 20 also claim aspects related to the biasing scheme. As noted in Claim 9, "applying a first bias causes the first spectrum to be dominant and applying a second bias causes the second spectrum to be dominant." The Band diagrams and Eigenstates presentation is familiar to those in the art and provides a useful manner of presentation. As shown in Fig.s 9a and 9b, with a change in the bias from +3Vdc to -3Vdc, the <u>ground state changes but the upper energy levels are unaffected</u> and continuous across the wells.

For at least the reasons presented herein the Applicant believes that the rejection has been traversed and allowance is respectfully requested.

<u>Claim Rejections – 35 USC § 103</u>

The Office has rejected claim 1-6, 8-17, 19 and 20 as being unpatentable over Martin (U.S. Pat. No. 6,469,358) in view of Kuan (U.S. Pat. No. 6,818,917) and also over Martin in view of Almogy ("Monolithic Integration of quantum well infrared photodetector and modulator", Appl. Phys. Lett., American Institute of Physics).

Applicant respectfully submits that the amended claims, as supported by the arguments herein, are distinguishable from the cited references. The statutory provisions are already of record.

As already noted, the Martin reference describes a three color quantum well device and the Office previously acknowledged that Martin does not describe asymmetric quantum well detector layers nor any other related properties or aspects thereto. Applicant also previously explained that Kuan does note describe the claimed elements of one or more detector layers including asymmetric quantum wells, each asymmetric quantum well being a unit cell comprising two quantum wells coupled by a barrier, where one of the quantum wells is configured to absorb a first spectrum, and the other quantum well is configured to absorb a

second spectrum. This is structurally distinguished from Kuan as already detailed in prior responses.

Kuan describes a bottom superlattice structure with a number of similar wells with similar barriers. All the quantum wells are the same and are arranged next to each other, and absorb the same frequency. There is a barrier layer and then a top superlattice structure having all similar quantum wells with similar barriers. The top superlattice also has all the same quantum wells adjacent to each other and intended to all absorb at the same frequency. In more particular detail: (see Kuan, Col. 6, lines 14-39.)

> Please refer to FIG. 10(a), which shows the band structure of our photodetector in accordance with an embodiment of the present invention. The system we described here is belonged to III/V semiconductor materials. The photodetector of the present invention contains sequentially a bottom contact layer 91, preferably is 500 nm, a bottom superlattice 92, preferably is 14-period, a blocking barrier 93, another top superlattice 94, preferably is 14-period, and a top contact layer 95, preferably is 400 nm. <u>Each period of the bottom 92 and top supelattices 94 is respectively composed of 6 nm GaAs well and 4 nm Al.sub.$_{0.27}$ Ga.sub.$_{0.73}$ As barrier, and 4.5 nm GaAs well and 6 nm Al.sub.$_{0.31}$ Ga.sub.$_{0.69}$ As barrier.</u>

Thus, Kuan describes a group of similar quantum wells for detecting one spectrum in one of the superlattices and another group of quantum wells for detecting another spectrum in the other superlattice structure. Further details of this multicolor photodetector are in the description of Kuan Fig. 10b and Fig. 11.

In stark contrast, one aspect of the present invention in relation to the Asymmetric Unit Cell is described in Figure 9 as follows: (present specification page 17, Par [0066])

> [0066] FIGS. 9a and 9b illustrate band diagrams, eigenstates, and electron distribution associated with an asymmetric quantum well structure configured in accordance with another embodiment of the present invention. Here, the asymmetric well is provided by virtue of a <u>unit cell that includes two coupled quantum wells. In particular, the design includes a first quantum well configured to absorb a first spectrum (e.g., blue), a second quantum well configured to absorb a second spectrum (e.g., red), and a coupling barrier between the two wells.</u> Outer barriers sandwich the coupled wells, and the second well includes a well spike.
> [0067] The "blue" and "red" wells can be, for example, GaAs. Only the red well is doped. The barriers sandwiching the wells can be, for example, Al.$_{30\%}$Ga.$_{70\%}$As. The

> coupling barrier between the wells, and the well spike in the red well can also be $Al_{.30\%}Ga_{.70\%}As$. The well spike of the red well effectively adjusts the ground state, and not the excited states associated with the red well.

Thus, the present invention comprises a unit cell with two adjacent quantum wells, wherein the adjacent quantum wells are not the same – they are photodetectors for two different spectrums. This is clearly distinguishable from the Kuan group of quantum wells in the top superlattice all being the same type, and the other group of quantum wells in the bottom superlattice being of the same type.

The Office also alleges that the 'interior high bandgap layers of each of the superlattice detectors in Kuan are considered "well spikes" and references Kuan Figures 10-15. This is incorrect as noted herein with the explanation of a well spike and as previously stated in prior responses.

As described in the present invention, the 'well spike' is a potential energy spike and is very thin in relation to the well in which it resides as noted in the figure herein and has a large and controllable effect on the energy level of the carriers within the well. This spike can be positive or negative, wherein a positive spike at the well center will raise the ground state energy and move the spectral response to a longer wavelength, and wherein a negative spike at the well center will lower the ground state energy and move the spectral response to a shorter wavelength. It effectively adjusts the ground state by using the biasing without affecting the other energy levels and thereby controls the spectral response. As noted in the present application in Par [0066], "[t]he well spike of the red well effectively adjusts the ground state, and not the excited states associated with the red well."

The term "band gap" refers to the energy difference between the top of the valence band and the bottom of the conduction band, where electrons are able to jump from one band to another. The well spike is wholly unrelated to the interior high or wide bandgap. Referring to Kuan Fig. 12, there is a plurality of wells in a top superlattice all with one bandgap 94' separated by a blocking layer 93' and followed by a plurality of wells in a bottom superlattice with another

bandgap 92'. The interior high bandgap of the multiple wells operates as known in the art. This is not a well spike as detailed herein that is a very small spike within a doped well that uses the bias to adjust a ground state and not the excited states. The present claims clarify the features that represent the unique characteristics of the claimed invention.

The Office also alleges that Almogy describes the well spike of doped material that is related to the present invention. Once again, this is incorrect. As already noted, Almogy does not ever use the term "well spike", and there is nothing in Almogy that is functionally related to the well spike of the present invention. The Almogy reference is related to a doping spike which refers to a technique to provide electrons to the quantum wells. A doping spike refers to a doping technique for providing charge carriers like electrons or holes. This doping technique is a method of confining donor/acceptor impurity atoms to an atomic layer of a host crystal. In contrast, the well spike is a very thin layer of a material such as the host crystal itself, wherein the spike layer resides in the only doped well of the structure and adjusts the ground state thereby changing the response.

Applicant believes the above amendments and remarks to be fully responsive to the Office Action, thereby placing this application in condition for allowance. No new matter is added.

Respectfully submitted,

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